PB86-219169

Using the Microcomputer during a Comprehensive Performance Evaluation The Need for Judgement

(U.S.) Environmental Protection Agency
Cncinnati, OH

Jul 86

U.S. Department of Commerce
National Technical Information Service
NTIS

PB86-219169
EPA/600/D-86/144
July 1986

USING THE MICROCOMPUTER DURING A COMPREHENSIVE PERFORMANCE EVALUATION: THE NEED FOR JUDGEMENT

by

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Prepared for
Pre-Conference Workshop on Computer Aided Training and Troubleshooting, 1986 N.E.T.A. 8th National Conference/Workshop, Minneapolis/St. Paul, Minnesota, August 24-28, 1986

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CINCINNATI, OHIO 45268

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INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA/600/D-86/144		PB86 219169/AS

4. TITLE AND SUBTITLE
Using the Microcomputer During a Comprehensive Performance Evaluation: The Need for Judgement

5. REPORT DATE
July 1986

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Jon H. Bender

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Wastewater Research Division
Water Engineering Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
Water Engineering Research Laboratory--Cinti. OH
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES Contact Jon Bender (513)569-7620
Presented Pre-Conference Workshop on Computer Aided Training and Troubleshooting, 1986 N.E.T.A. 8th National Conference, Minneapolis/St. Paul, Minn. August 24-28, 1986.

16. ABSTRACT

U.S.EPA developed the composite correction program (CCP) approach for improving POTW performance and published a handbook which describes how to implement the CCP approach. A comprehensive performance evaluation (CPE), which is the first part of the CCP approach, evaluates the capacities of the major unit processes and identifies and prioritizes the factors limiting a POTW's performance. Completing a CPE consists of five steps. A computer program was also developed by EPA to assist in one of the completing steps; the major unit process evaluation. This paper discusses the background research that led to the development of the CCP approach, the five steps of a CPE, and how to use the EPA major unit process evaluation computer program. It also emphasizes how and why the person completing a CPE must exercise their judgement; even when assisted by a computer.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release to Public	Unclassified	64
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)

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BACKGROUND: CAUSES OF NON-COMPLIANCE

The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) established specific goals for pollution abatement programs to "restore and maintain the chemical, physical and biological integrity of the nation's waters." One of these programs, the National Pollutant Discharge Elimination System (NPDES), monitors the effluent quality of wastewater discharges to the nation's waters to assure that these water quality objectives are met. PL 92-500 also established the Federal construction grants program that funds municipal wastewater treatment plants to assure that communities could comply with their NPDES permits. Since passage of PL 92-500 the Federal government, through fiscal year 1985, has spent $45 billion on construction of municipal wastewater treatment plants (1).

Has this investment in wastewater treatment resulted in the achievement of the Nation's water quality goals? Section 210 of PL 92-500 requires the Environmental Protection Agency to conduct an annual survey and report to Congress on the efficiency of facilities constructed with Federal funds. Gilbert (2) summarized the first three of these EPA 210 Reports to Congress for the years 1973, 1974 and 1975 which indicated that one-third of the municipal wastewater treatment facilities constructed with Federal funds were not operating at their designed efficiency levels. Reports by the Government Accounting Office (GAO) in 1977, 1980, and 1983 indicate that approximately 30% of the municipal wastewater treatment plants violated their NPDES permit (3, 4, 5). A recent survey by U.S. EPA's Management Advisory Group found that nearly 46% of all major POTWs are not in compliance with the water quality goals of the Clean Water Act (6).

After the first reports of persistent compliance problems at municipal

wastewater treatment plants, U.S. EPA's Water Engineering Research Laboratory (WERL) funded research to determine the causes of these problems. The project's title "National Operation and Maintenance Cause and Effect Survey" reflected WERL's perception that the municipal compliance problem was strictly an operation and maintenance (O&M) problem. We envisioned that a national program to correct deficiencies in O&M at municipal wastewater treatment plants would solve their compliance problems.

Two contractors completed the project over a three and one-half year period; one evaluated municipal wastewater treatment plants in the eastern United States and the other evaluated plants in the west. The plants evaluated were selected based on a sequential screening and selection process. EPA regional offices and state regulatory agencies provided initial lists of potential plants. The contractors selected plants from these lists based on the following criteria:

1. The plant must incorporate some variation of suspended growth, fixed film, or aerated lagoon biological treatment.
2. The plant should not be severely hydraulically or organically overloaded, nor have obvious identifiable structural or component deficiencies.
3. The plants should range in size up to 10 mgd and all major units should be operating.
4. No enforcement action should be underway or pending against the municipality or authority involved.

Based on these criteria the two contractors selected and evaluated a total of 103 treatment plants. Each evaluation was completed by a two person team and lasted three to five days depending on the size and

complexity of the plant. The evaluation consisted of an assessment of the performance capabilities of the major unit processes and a weighting of the relative impact on performance of 70 different factors potentially limiting the plant's performance. These factors covered most aspects of the plant's design, administration, operation and maintenance. A weighting scale of from 0 to 3 was used to assess the relative impact of the factor on the plant's performance. The following definitions were used to assign the weights to the various factors:

Weighting Scale	Effect of Specific Factor on Plant Performance
0	No significant effect on plant performance
1	Minor effect on plant performance
2	Minimum indirect effect on plant performance on continuous basis or major direct effect on plant performance on a periodic basis
3	Major direct effect on plant performance

References 7, 8, 9, and 10 present the details and results of this project for the two contractors and two phases required for its completion. Evans (11) summarized all of the results of this project. He develops Figure 1 which ranks the 70 factors in decreasing order of severity of their impact on performance. The overall ranking takes into account the number of times the factor was noted to limit performance and the weighting it received (0, 1, 2, or 3) at each plant. It also shows the number of plants where each factor was found to limit the plant's performance as well as the number of plants where the factor was the leading cause of poor performance.

Limiting Factor			No. of Times	
Factor	Area	Description	Factor was ranked #1	Factor was noted
1	Operation	Operator Application of Concepts & Testing to Process Control	24	89
2	Operation	Process Control Testing	0	87
3	Design	Infiltration/Inflow	9	56
4	Operation	Sewage Treatment Understanding	9	50
5	Operation	Technical Guidance	7	47
6	Design	Sludge Wasting & Return Capability	9	43
7	Design	Secondary Process Controllability	3	55
8	Design	Secondary Process Flexibility	3	37
9	Operation	O&M Manual Inadequacy(*)	0	40
10	Design	Aerator	6	27
11	Design	Sludge Treatment(*)	3	36
12	Design	Industrial Loading	4	27
13	Operation	Staff Training	0	31
14	Design	Secondary Clarifier	3	26
15	Operation	Performance Monitoring	0	31
16	Design	Ultimate Sludge Disposal	1	30
17	Administration	Plant Administration, Familiarity with Needs	2	21
18	Design	Disinfection(*)	1	20
19	Administration	Plant Staff - Number	2	22
20	Design	Plant Hydraulic Loading	0	18
21	Administration	Plant Staff - Plant Coverage	0	26
22	Maintenance	Spare Parts Inventory	0	23
23	Design	Laboratory Space & Equipment	0	30
24	Design	Return Process Stream	1	18
25	Operation	Equipment Malfunction	2	17
26	Maintenance	Lack of Preventive Maintenance Program	1	20
27	Design	Alternative Power Source	0	24
28	Design	Organic Loading	7	13
29	Maintenance	General Housekeeping	0	17
30	Maintenance	Maintenance Scheduling & Recording	0	19
31	Administration	Administration Policies	2	15
32	Administration	Plant Staff Productivity	0	17
33	Administration	Insufficient Funding	1	16
34	Maintenance	Manpower	0	14
35	Design	Preliminary Unit Design(*)	0	20
36	Administration	Staff Motivation	0	19
37	Administration	Working Conditions	0	18
38	Design	Alarm Systems	0	19
39	Maintenance	Critical Parts Procurement	0	14
40	Design	Flow Proportioning to Units	0	12
41	Operation	Staff Aptitude	0	13
42	Design	Inoperability Due to Weather	0	12
43	Administration	Staff Supervision	0	13
44	Design	Primary Units(*)	1	9
45	Maintenance	Equipment Age	0	14
46	Operation	O&M Manual - Use by Operators(*)	0	12
47	Administration	Salary	0	12
48	Design	Lack of Standby Units for Key Equipment	0	9
49	Design	Lack of Unit By-Pass	0	12
50	Maintenance	Technical Guidance - Emergencies	0	10
51	Maintenance	Availability of Preventive Maintenance Ref.	0	10
52	Design	Flow Backup	0	7
53	Operation	Staff - Level of Education	0	9
54	Design	Toxic Loading	0	8
55	Design	Submerged Weirs	0	6
56	Design	Plant Location	0	6
57	Operation	Staff Level of Certification	0	8
58	Operation	Staff - Insufficient Time on Job	0	7
59	Maintenance	Staff Expertise - Emergencies	0	9
60	Design	Seasonal Variation Loading	0	7
61	Administration	Unnecessary Expenditures	0	7
62	Design	Process Automation for Control	1	6
63	Administration	Personnel Turnover	0	4
64	Operation	Shift Staff Adequacy	0	3
65	Design	Unit Accessibility	0	3
66	Design	Process Accessibility for Sampling	0	4
67	Design	Process Automation for Monitoring	0	2
68	Design	Equipment Accessibility for Maintenance	0	2
69	Administration	Bond Indebtedness	0	0
70	Design	AWT Units(*)	0	0

*Not included in every plant evaluated

Figure 1. National O&M Cause and Effect Survey Results - Collective Ranking of Factors Limiting Plant Performance (11).

Evans (11) discusses in detail the top 10 factors, from Figure 1, limiting the performance at these facilities as follows:

Factor No. 1. Operator application of Concepts and Testing to Process Control--This factor was ranked as the most severe deficiency and leading cause of poor performance at 23 facilities and was a high-ranked factor at a total of 89 out of the 103 plants evaluated. It occurs when a trained operator in a satisfactorily designed plant permits less than optimum performance. This factor was ranked when incorrect control adjustment or incorrect control test interpretation occured, or when the use of existing inadequate design features continued when seemingly obvious operations alternatives or minor plant modifications could have been implemented to improve performance. The lack of testing and control were not necessarily the result of inadequate training or comprehension in these areas, but simply the lack of or inability to apply learned techniques.

Factor No. 2. Process Control Testing Procedures--Inadequate process control testing involves the absence or wrong type of sampling or testing for process monitoring and operational control. This deficiency leads to making inappropriate decisions. Standard unit process tests such as mixed liquor suspended solids, mixed liquor dissolved oxygen, mixed liquor settleable solids, and return sludge suspended solids for activated sludge processes were

seldom or never conducted. Also, important operating parameters such as sludge volume index, F:M ratio and mean cell retention time in suspended growth systems or recirculation rates in trickling filter plants were usually not determined. This factor adversely impacted performance at 67 of the 103 plants evaluated.

Factor No. 3. Infiltration/Inflow--The results of this widespread problem are manifested by severe fluctuations in flow rates, periods of severe hydraulic overloading, and dilution of the influent wastewater so that both suspended and fixed biological systems are loaded to less than optimal values. The extreme result is the "washout" of suspended growth systems as a result of the loss of solids from the final clarification stage during high flow periods. This factor was ranked first at 56 of the 103 plants evaluated.

Factor No. 4. Inadequate Understanding of Wastewater Treatment--This factor is distinguished from Factor #1 in that it is defined as a deficiency in the level of knowledge that individual staffs at various facilities exhibit concerning wastewater treatment fundamentals. On occasion, an operator's primary concern is simply to keep the equipment functional rather than to learn how the equipment relates to the processes and their control. This factor adversely affected performance at 50 plants and was the leading cause of poor performance at nine facilities.

Factor No. 5. Technical Guidance--Improper technical guidance includes misinformation from authoritative sources including design engineers, state and federal regulatory agency personnel, equipment suppliers, operator training staff and other plant operators. At any one plant, improper technical guidance was observed to come from more than one source. This factor was ranked as the most severe deficiency at seven plants, and was an adverse factor at 47 facilities.

Factor No. 6. Sludge Wasting Capability--This factor was ranked as the leading cause of poor performance at nine facilities and was a factor at 43 plants studied. This factor included inadequate sludge handling facilities and the inability to measure and control the volume of waste sludge. Either one or both of these conditions was noted as having a major impact on performance at several plants.

Factor No. 7. Process Controllability--The lack of controllability was evident in the inability to adequately measure and control flow streams such as return sludge flow and trickling filter recirculation rates. While measurement and control of return activated sludge flow were the most frequent reasons for rating this factor, process controllability was not a major cause of poor performance. It prevented an operator from "tuning" his treatment system to the varying demands

which were placed on it by hydraulic and organic loading fluctuations. This factor occurred at 55 plants and was the leading factor at three facilities.

Factor No. 8. Process Flexibility--Lack of flexibility refers to the unavailability of valves, piping and other appurtenances required to operate in various modes or to include or exclude existing processes as necessary to optimize performance. Poor flexibility precludes the ability to operate an activated sludge plant in the contact stabilization, step loading or conventional modes and the ability to bypass polishing ponds or other downstream processes to discharge high quality secondary clarifier effluent. Either the lack of, or inadequate, process flexibility was noted as the leading cause of poor performance at three plants and was a factor at 37 facilities.

Factor No. 9. Ineffective O&M Manual Instruction--This situation, existing at 40 plants, was judged serious although the adverse effect was moderate. The poor quality of most plants' O&M manuals undoubtedly has contributed to operators' general lack of understanding of the importance of process control and the inability to practice it, but a competent staff could use other other available information sources.

Factor No. 10. Aerator Design--Deficiencies in aerator design were the major cause of poor performance at six facilities and

were less significant factors at an additional 21 plants. Deficiencies were noted in the type, size, shape, capacity, and location of the unit and were of such a nature as to hinder adequate treatment of the waste flow and loading and stable operation.

As stated previously, this study assumed that deficiencies in O&M common to all plants caused compliance problems at municipal wastewater treatment plants throughout the United States. Though the top ranked factor found limiting performance was operations oriented and noted at 89 of the 103 plants it was only the major factor at 24 plants. Also note that several different design related factors were frequently found to limit performance. Administration and maintenance factors are also relatively highly ranked. The major conclusion from this project was that, at each plant evaluated, a unique combination of factors limited that plants performance. None of the plants evaluated had a single factor limiting its performance nor were the same combination of factors found at any of the plants. Clearly, the municipal compliance problem was not strictly an O&M problem, but the poor performance observed at municipal wastewater treatment plants was related to a combination of design, operation, maintenance, and administration problems unique to each individual plant.

The next phase of the WERL research developed an approach for achieving compliance at municipal wastewater treatment plants. To explain the requirements for a program to improve a plant's performance Hegg et al. (7) developed the Unified Concept depicted by the triangle shown in Figure 2. The top of the triangle represents the ultimate goal of a correction program; optimum performance. Current performance of the plant is depicted by the base of

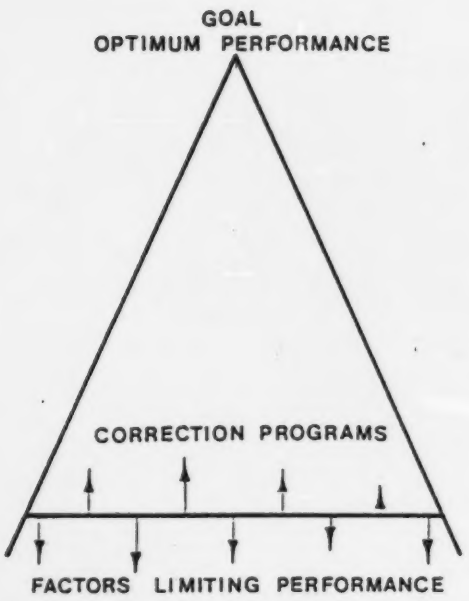


Figure 2. Unified Concept for Achieving Optimum Plant Performance (7).

the triangle which represents its relative distance away from the goal of optimum performance. Location of the base is determined by the number of factors limiting the plant's performance.

The Unified Concept shows that a correction program that only addresses some of the factors limiting performance, such as operator training, will improve performance, but can not achieve the goal of optimum performance if other design, operation, maintenance, and administrative factors are also limiting the plant performance. A correction program must address all of the factors limiting a plant's performance before that plant can achieve its optimum level of performance.

COMPOSITE CORRECTION PROGRAM (CCP) APPROACH FOR ACHIEVING COMPLIANCE

A composite correction program (CCP) addresses all of the factors limiting a plant's performance allowing it to achieve optimum performance. It is implemented over a 12 to 18 month period under the direction of a facilitator. A comprehensive performance evaluation (CPE) serves as the basis of the CCP. The CPE evaluates the capability of the existing unit processes to handle the current wastewater flows and loads and produce the required effluent quality. It also identifies those factors limiting the plant's performance. These factors are then ranked according to their relative adverse impact on performance.

Based on the CPE results, the facilitator directs the CCP making sure that any design deficiencies are corrected along with the factors found to limit the plant's performance. The facilitator works with the plant operators and the municipality's administrators to correct the factors identified. None of the plant modifications and/or process control changes are made unilaterally by the facilitator.

The 12 to 18 month requirement of the CCP stems from the following reasons:

- The inherently long response times associated with making changes and achieving stability in biological systems.
- The time required to make physical and procedural changes.
- The greater effectiveness of more training opportunities.
- The time required for identification and elimination of any additional performance-limiting factors that may be found during the CCP.

HOW TO CONDUCT A COMPREHENSIVE PERFORMANCE EVALUATION (CPE)

U.S. EPA published the "Handbook, Improving POTW Performance Using the Composite Correction Program Approach" (12) which provides specific procedures for conducting a CPE at different types of mechanical wastewater treatment plants. A CPE is conducted at the treatment plant over a three to five day period by a two person team depending on the size and complexity of the facility. During this period, the evaluation team collects data and information on the design, performance, operation, maintenance and administration of the plant. Plant tours and interviews with plant operators, managers, and city administrators are used to collect this informtion. The Handbook contains data sheets which contain the necessary information for a successful CPE.

Major Unit Process Evaluation

The first step of a CPE, the major unit process evaluation, determines whether the existing major unit processes have sufficient capacity to consistently produce the required effluent quality. Without adequate treatment capacity a CCP cannot be successful.

Based on the major unit process evaluation, the plant is classified as either type 1, type 2, or type 3. Type 1 plants can achieve the desired performance with the existing unit processes. A CCP can be implemented at type 1 plants without major upgrading and the desired levels of performance achieved. A type 2 plant has marginal amounts of treatment capacity, but a CCP may still improve performance though probably not to the desired levels without significant plant improvements. Type 3 plants have totally inadequate major unit processes. The performance of these facilities will not improve with a CCP without the addition of significant amounts of treatment capacity. Implementation of a CCP, therefore, would not be recommended at type 3 plants. It should be emphasized that this evaluation is not intended to determine if the plant meets certain design criteria, but rather it is intended to evaluate if a CCP can be successful at the existing facility.

The major unit process evaluation only evaluates three unit processes at the plant; the aerator, the clarifier, and the sludge handling system. Other unit processes such as the grit chamber located at the plant are important, but have not been found to have a significant direct impact on performance and have not been included in the major unit process evaluation.

A point system is used to quantify the evaluation of these three basic unit processes. Key loading and process parameters are calculated and results for each parameter assigned a score by comparison with standard tables. Subsequently, each of the three major unit processes receives a total score by adding together the points assigned the loading and process parameters. The totals are then compared with standards to assess whether

a type 1, type 2, or type 3 capability is indicated for that unit process. The overall plant type is determined by the "weakest link" among the three major process areas.

The following presents the point system used for activated sludge systems. Other scoring procedures are presented in the Handbook (12) for other types of mechanical treatment plants (trickling filter, RBC, and ABF processes).

Major Unit Process Evaluation for Activated Sludge Systems--

Scoring of the capability of the aeration basin is based upon the hydraulic detention time, organic loading, and oxygen availability based on the current operating conditions at the plant. Figure 3 presents the parameters on which the point scores are based. Determining the point score for the "aerator" requires calculation of the hydraulic detention time, organic loading, and oxygen availability, finding the corresponding point score for each parameter and then summing the three point scores to arrive at a total point score.

Parameters used to score the capability of the activated sludge secondary clarifier are configuration, surface overflow rate, depth, type of sludge removal mechanism and return activated sludge control provided. A point score is assigned for each of these parameters, shown in Figure 4, which are then summed to obtain a total point score for the "clarifier."

The capability of the sludge handling facilities for an activated sludge system is scored based on the controllability of the wasting process and the capacity of the available sludge treatment and disposal facilities. Figure 5 shows the point score assigned for these parameters.

Current Operating Condition	Points *
Hydraulic Detention Time, hr:	
24	10 (max.)
10	6
5	0
3	-6
Organic Loading, kg $BOD_5/m^3/d$ (lb/d/1,000 cu ft):	
0.24 (15)	10 (max.)
0.40 (25)	6
0.80 (50)	0
1.28 (80)	-6
Oxygen Availability, kg O_2/kg BOD_5 load:	
2.5	10 (max.)
1.5	5
1.2	0
1.0	-5
0.8	-10

*Interpolate to nearest whole number between loadings listed.

Figure 3. Parameters for Scoring Capability of Aeration Basins in Suspended Growth POTW's (12).

Current Operating Condition	Points
Configuration:	
Circular with "donut" or interior launders	10
Circular with weirs on walls	7
Rectangular with 33% covered with launders	0
Rectangular with 20% covered with launders	-5
Rectangular with launder at or near end	-10
Surface Overflow Rate, $m^3/m^2/d$ (gpd/sq ft):	
12 (300)	15
20 (500)	10
27 (650)	5
33 (800)	0
41 (1,000)	-10
49 (1,200)	-15
Depth at Weirs, m (ft):	
4.6 (15)	10
3.7 (12)	4
3.0 (10)	0
2.4 (8)	-5
2.1 (7)	-10
Return Sludge Removal:	
Circular, rapid withdrawal	10
Circular, scraper to hopper	8
Rectangular, cocurrent scraper	2
Rectangular, countercurrent scraper	0
No mechanical removal	-5
Return Activated Sludge Control:	
Actual RAS flow range completely within recommended RAS flow range; capability to measure RAS flow	10
Actual RAS flow range completely within recommended RAS flow range; no capability to measure RAS flow	7
50% of recommended RAS flow range covered by actual RAS flow range; capability to measure RA	5
50% of recommended RAS flow range covered by actual RAS flow range; no capability to measure RAS flow	0
Actual RAS flow range completely outside recommended RAS flow range	-5

Figure 4. Parameters for Scoring Capability of Clarifiers in Suspended Growth POTW's (12).

Current Operating Condition	Points
Controllability:	
Automated sampling and volume control	5
Metered volume and hand sampling	3
Hand measured volume and hand sampling	2
Sampling or volume measurement by hand not practical	0
Capacity:	
150% of calculated long-term average sludge production	25
125% of calculated long-term average sludge production	20
100% of calculated long-term average sludge production	15
75% of calculated long-term average sludge production	0
50% of calculated long-term average sludge production	-10

Figure 5. Criteria for Scoring Sludge Handling Capability for Suspended Growth POTW's (12).

The following procedures are used to evaluate the capacity of the sludge handling facilities:

- Calculate the expected sludge production.
- Establish the capacity of each of the existing sludge handling unit processes using the parameters shown in Figure 5.
- Determine the percentage of the calculated sludge production each unit process can handle based on the values given in Figure 6.
- Identify unit process with the lowest percentage capacity to handle calculated sludge production and assign a point score from Figure 5 based on that process.

A total point score for the sludge handling facilities is based on the score for controllability and capacity.

With the point scores assessed for the individual unit processes the type of plant (1, 2, or 3) can be determined. Figure 7 shows a range of scores and the corresponding type for each of the major unit processes and the total plant. In the second part of Figure 7, the types for each major unit process and the total plant are listed. The type of plant is determined based on the worst unit process. In other words, if the aerator and clarifier are type 1 and the sludge handling type 3, the entire plant is considered type 3 even if the point score for the entire plant is high enough to make it a type 1.

Identification of Performance-Limiting Factors

In the second step of a CPE the evaluators identify the factors

Process	Parameters That Can Be Used to Represent 100% of Required Sludge Handling Capacity[a]
Gravity Thickeners	
Primary Sludge	125 kg/m^2/d (25 lb/d/sq ft)
Activated Sludge	20 kg/m^2/d (4 lb/d/sq ft)
Primary + Activated	50 kg/m^2/d (10 lb/d/sq ft)
Fixed Film	40 kg/m^2/d (8 lb/d/sq ft)
Primary + Fixed Film	75 kg/m^2/d (15 lb/d/sq ft)
Dissolved Air Flotation	
Primary Sludge	125 kg/m^2/d (25 lb/d/sq ft)
Activated Sludge	50 kg/m^2/d (10 lb/d/sq ft)
Primary + Activated	100 kg/m^2/d (20 lb/d/sq ft)
Fixed Film	75 kg/m^2/d (15 lb/d/sq ft)
Primary + Fixed Film	125 kg/m^2/d (25 lb/d/sq ft)
Digesters	
Aerobic	15 days' hydraulic detention time[b]
Anaerobic	
Single Stage	40 days' hydraulic detention time
Two Stage	30 days' combined hydraulic detention time
Drying Beds	Worst season turnover time
Mechanical Dewatering	
Single Unit	30 hours of operation/week
Multiple Units	60 hours of operation/week (with one unit out of service)
Liquid Sludge Haul	
Short Haul (<3 km)	6 trips/day maximum
Long Haul (>20 km)	4 trips/day maximum

[a]Capacity of existing unit processes should not be downgraded to these values if good operation and process performance are documented at higher loadings. For example, if records appear accurate and show that all sludge production has been successfully thickened in a gravity activated sludge thickener for the past year at an average loading of 25 kg/m^2/d (5 lb/d/sq ft), the existing thickener should be considered to have 100% of required capacity.

[b]Hydraulic detention time = Volume of digester/Volume of waste sludge expected to be produced.

Figure 6. Guidelines for Evaluating Capacity of Existing Sludge Handling Processes (12).

	Score	Points Required		
		Type 1	Type 2	Type 3
Aeration Basin	_____ (4)	13-30	0-12	<0
Secondary Clarifier	_____ (10)	25-55	0-24	<0
Sludge Handling Capability	_____ (13)	10-30	0- 9	<0
Total	_____	60-115	20-59	<20

	Type
Aeration Basin	_____
Secondary Clarifier	_____
Sludge Handling Capability	_____
Total	_____

Select the Worst Case: POTW is Type_____

Figure 7. Criteria for Point Scores to Determine Plant Type for Suspended Growth POTW's. (12).

limiting the performance of the plant. The Handbook contains a listing and definitions of 70 different factors that could potentially limit the plant's performance. They cover the four areas of design, operation, maintenance, and administration.

The evaluators identify the actual factor limiting that plant's performance from the list of 70 based on clues and information obtained during the plant tour and interviews with the various personnel. They use the checklist of 70 factors and definitions in the Handbook to guide them through the potential factors. Though there are 70 potential factors, the evaluation team's goal is to identify the 5-15 factors truly limiting the plant's performance. They attempt to eliminate the other non-performance-limiting factors so that they can focus on the true cause of poor performance. A two person team is essential to accurately identify the factors limiting the performance at a plant.

Completing the identification of factors is difficult in that the true causes of the problems are often masked. Rarely are the factors readily apparent without discussions between the evaluators. The following discussion serves to illustrate this point:

> A contact stabilization plant was routinely losing sludge solids over the final clarifier weirs, through the chlorine contact tank, and to the receiving stream, resulting in non-compliance with the plant's permit. Initial observations could lead to the conclusion that the plant had an inadequately sized final clarifier. However, further investigation indicated that the solids loss was a result of the operators routinely wasting less sludge than was produced. It was determined that, to properly

control the sludge mass, increased operator time and additional equipment to adequately monitor the waste activated sludge to the digester would be required. It was further determined that the digester was undersized and would not provide adequate residence time for complete digestion.

The most obvious problem is the operators lack of knowledge of how to apply the concept of sludge mass control. The needed laboratory equipment was within the approved budget for the facility and therefore was not assessed as a major problem. Plant administrators indicated that they could not afford additional operator time. This administrative policy was a significant factor limiting performance. The undersized digester was not a significant problem in this case because unlimited cropland for disposal of partially digested sludge was available. (Note: Disposal of partially digested sludge on cropland can no longer be considered a permanent solution since enactment of Federal regulations for land disposal of POTW sludges). It was concluded that four factors contributed to the solids loss that caused poor plant effluent quality:

1. Inadequate operator knowledge to apply the concept of sludge mass control.
2. Restrictive administrative policy that prohibited needed operator time.
3. Inadequate test equipment.
4. Inadequate digester capacity.

The above discussion illustrates that a comprehensive analysis of a

performance problem is essential to identify the true performance-limiting factors. If the initial problem of lack of clarifier capacity had been identified, improper corrective actions and unnecessary expenditures of funds would likely have occurred. In almost all CPEs, several factors are identified as limiting performance. Initially, each factor identified should be listed without regard to order of severity.

It is emphasized that the purpose of identifying performance-limiting factors is to identify, as accurately as possible, causes of poor performance unique to a particular plant. Observation that a factor does not meet the "industry standard" does not necessarily constitute cause for identifying that factor as limiting the POTW's performance. An actual link between poor plant performance and an identified factor must exist.

Prioritization of Performance-Limiting Factors

The third step of a CPE prioritizes the factors previously identified as limiting the plant's ability to achieve the desired levels of performance. This prioritization establishes the types of follow-up activities necessary to achieve these levels of performance. For example, if the highest ranking factors, i.e., those having the most negative impact on performance, are related to physical limitations in unit process capacity, initial corrective actions are directed toward defining plant modifications and obtaining administrative funding and action for their implementation. If the highest ranking factors are process control oriented, the initial emphasis of follow-up activities would be directed toward plant-specific operator training.

Before the identified factors are prioritized they are each first assessed with regards to their adverse impact on plant performance. The

evaluation team decides the relative adverse impact on performance of each factor using the following rating criteria:

Rating	Adverse Effect of Factor on Plant Performance
A	Major effect on long-term repetitive basis
B	Minimum effect on routine basis or major effect on a periodic basis
C	Minor effect

Each factor previously identified as limiting performance is then assigned an "A," "B," or "C" rating.

Following assigning the ratings to the factors, the evaluation team prioritizes only the "A" and "B" factors. "C" factors are not prioritized because of their minor adverse impact on performance and the fact that they probably will not have to be corrected for the plant to achieve the desired levels of performance. Following the prioritization the evaluation team will produce a summary sheet of the factor limiting the performance of the plant in order of severity.

Assessing the Ability of CCP to Improve Performance

By definition of a CCP, all performance-limiting factors can theoretically be eliminated and the desired level of performance achieved. The fourth part of a CPE, however, specifically assesses whether or not each factor identified and prioritized can be corrected. In actuality, there may be practical reasons why a city will not address an important factor which would prevent a CCP from being possible.

An effective approach is to systematically evaluate each identified factor individually to determine whether there are any practical reasons

a factor cannot be addressed. Examples of factors that may not be feasible to address are replacement of key personnel, drastic increases in funding, or extensive training of owners or administrators to support POTW needs.

Some factors have a variety of potential solutions or combinations of corrective actions that can effectively address the problem. For example, an activated sludge clarifier may be improved by installing baffles to decrease short-circuiting, by utilizing partial flow equalization to reduce hydraulic peaks, or by switching to other activated sludge mass modes to better control sludge settling characteristics and to reduce clarifier loading. Often a combination of these corrective actions would be appropriate. The systematic assessment of the prioritized factors helps assure that all factors can realistically be addressed, thus providing the basis for the comprehensive approach to improving performance.

CPE Report

The last part of a CPE should be a brief, written report summarizing the CPE results to provide guidance for facility owners and administrators. A typical CPE report contains 8-12 pages and includes the following topics:

- Facility Background
- Major Unit Process Evaluation
- Performance-Limiting Factors
- Projected Impact of a CCP
- CCP Costs

A CPE report should not provide a list of specific recommendations for correcting individual performance-limiting factors. This often leads to a piecemeal approach to corrective actions where the goal of improved performance is not met. For type 1 and type 2 plants, the necessity of

comprehensively addressing the combination of factors identified by the CPE through the implementation of a CCP should be stressed. For type 3 plants, a recommendation for a more detailed engineering study to support the anticipated upgrade may be warranted.

USING THE MICROCOMPUTER TO COMPLETE THE MAJOR UNIT PROCESS EVALUATION

As described above a CPE consists of the following five parts:

- Major Unit Process Evaluation
- Identification of Performance - Limiting Factors
- Prioritization of Performance - Limiting Factors
- Assessing Ability of CCP to Improve Performance
- CPE Report

Of these five parts of a CPE the microcomputer is only useful as a tool in completing the major unit process evaluation. The major unit process evaluation requires many calculations which could potentially be completed much quicker using a computer.

The CCP approach was developed from the research described earlier which was funded by the Water Engineering Research Laboratory (WERL) of U.S.EPA. Subsequent to this research, U.S.EPA's Center for Environmental Research Information (CERI) funded development and publication of "Handbook, Improving POTW Performance Using the Composite Correction Program Approach" (12). A series of 14 seminars, funded by CERI and presented nationally, discussed how to use the CCP approach. CERI also identified the possibility of using a microcomputer to assist in the completion of the major unit process evaluation part of a CPE. They then developed the computer program titled "POTW Major Unit Process Evaluation Computer Program." All computer software for this program was developed by the CERI staff.

CERI has made this software available, at no charge, to anyone who sends them a blank disk along with the order form presented in attachment A. The software for this program will be copied on your blank disk and sent back to you along with the instructions presented in attachment B.

The program was designed for IBM personal computers and is not available for other non-IBM compatible computers. Attachment B presents a listing of equipment needed to use this program.

The program allows the computer to present a series of screens that prompt the user what information the computer needs to complete the major unit process evaluation. Information needed includes the wastewater flow rates and pollutant concentrations, types of major unit processes and their size. Based on this information the program computes whether the facility is a Type 1, Type 2, or Type 3 as defined in a previous section of this paper. It then generates a report that shows the data and results for each of the three different major unit processes; the aerator, the clarifier, and the sludge handling system.

Attachment B presents detailed instructions relative to the various screens where the user enters data on a particular plant. The following presents the various screens and the type of information the user must enter.

Selection Menu Screen

Figure 8 shows the screen that the computer will provide the user at the beginning of the program. The user must choose one of the five selections.

1) Edit Old Evaluation
2) New Evaluation
3) Return to DOS
4) Delete File
5) Printer Output of Old Evaluation

Enter the number of the selection; press Return

Figure 8. Selection Menu Screen.

File Name Screen

The computer provides the file name screen, shown in Figure 9, if selections #1, #4, or #5 are chosen. This screen also shows under "files:" the plants that the user has previously entered.

POTW Name Screen

When the user selects #2 from the menu, the computer provided the POTW name screen, shown in Figure 10. After entering the name, the program truncates it to eight characters for a file name (see Figure 9).

POTW Type Screen

When choosing selection #1 or #2, the computer will next provide the user the POTW type screen, shown in Figure 11. The "POTW Name" will be either one selected from file, which will have all data entered, or a new plant for which the user must enter the data. This screen shows the seven types of POTW's that this computer program can handle.

Component Selection/System Configuration Screen

After the user enters the type of plant being evaluated, the computer asks for some additional information regarding the other unit processes in the plant. The component selection/system configuration screen, shown in Figure 12, consists of three separate screens that contain the same information, but ask different questions. At the top of each screen is the "POTW name" and "POTW type" previously entered. Below these the computer lists 14 different lines of information. For the first nine lines the user must answer yes or no as to whether the plant being evaluated has the unit processes listed. The next two lines also require the user to provide a yes or no answer. In the last three lines, the user must select a number from the menu at the bottom for the screen. A separate screen is

FILE NAME:

FILES:

BENDER	BRAGGS	CAL	CAL2	CERI
CIOBAN	COTTONPO	FKENT	GREENWOO	HOLDENVI
KERWIN	MANNFORD	MURRAY	NANCY	NITRO
PAWNEE	PIERRE	PLANTC	PLANTCC	RICK
SEMA	SEMB	SEMINARA	SEMINARB	SEMINARC
TEST	TESTER	THJ	WOLCOTT	WWTPN

Enter POTW Name - Press Return When Finished

Figure 9. File Name Screen.

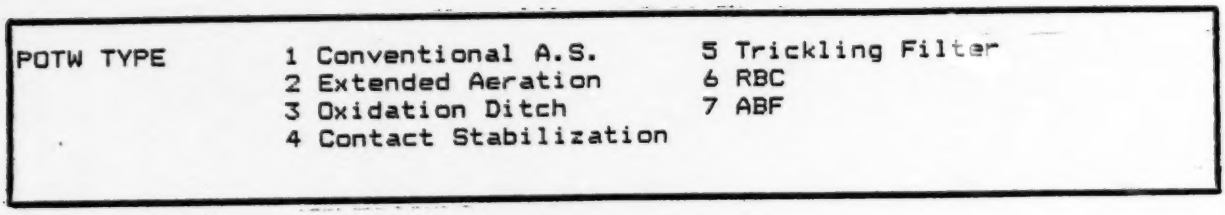
POTW NAME:

Enter POTW Name - Press Return When Finished

Figure 10. POTW Name Screen

POTW Name:

POTW Type:



[Esc] to Abort---[PgDn] for Next Screen

Figure 11. POTW Type Screen.

Screen 1

POTW Name:

POTW Type:

Primary Clarification
Gravity Thickening
Dissolved Air Flotation
Anaerobic Digestion
Aerobic Digestion
Sludge Drying Beds
Sludge Lagoons
Vacuum Filtration
Belt Filter Presses
Secondary Sludge to Primary
Ability to Measure RAS Flows
Final Clarifier Configuration
RAS Removal Method
Sludge Controllability

FINAL CLARIFIER CONFIGURATION	1 Circular with 'Donut' or Interior Launders 2 Circular with Weirs on Walls 3 Rectangular with 33% Covered with Launders 4 Rectangular with 28% Covered with Launders 5 Rectangular with Launder at or Near End

[Esc] to Abort——[PgDn] For Next Screen——[PgUp] For Previous Screen

Screen 2

POTW Name:

POTW Type:

Primary Clarification
Gravity Thickening
Dissolved Air Flotation
Anaerobic Digestion
Aerobic Digestion
Sludge Drying Beds
Sludge Lagoons
Vacuum Filtration
Belt Filter Presses
Secondary Sludge to Primary
Ability to Measure RAS Flows
Final Clarifier Configuration
RAS Removal Method
Sludge Controllability

RAS REMOVAL METHOD	1 Circular Clarifier - Rapid Withdrawal 2 Circular Clarifier - Scraper to Hopper 3 Rectangular Clarifier - Co-Current Scraper 4 Rectangular Clarifier - Counter-Current Scraper 5 No Mechanical Removal

[Esc] to Abort——[PgDn] For Next Screen——[PgUp] For Previous Screen

Screen 3

POTW Name:

POTW Type:

Primary Clarification
Gravity Thickening
Dissolved Air Flotation
Anaerobic Digestion
Aerobic Digestion
Sludge Drying Beds
Sludge Lagoons
Vacuum Filtration
Belt Filter Presses
Secondary Sludge to Primary
Ability to Measure RAS Flows
Final Clarifier Configuration
RAS Removal Method
Sludge Controllability

SLUDGE CONTROLLABILITY	1 Automated Sampling and Volume Control 2 Metered Volume and Hand Sampling 3 Hand Measured Volume and Hand Sampling 4 Sampling or Volume Measurement Not Practical

[Esc] to Abort——[PgDn] For Next Screen——[PgUp] For Previous Screen

Figure 12. Component Selection/System Configuration Screens.

provided for each of these three lines. When the user moves to the second screen the computer displays all of the same information for the top 12 lines of information. After completion of the third screen all 14 lines of information should be completed.

If the plant being evaluated has unit processes other than those listed here, this computer program cannot be used to complete the major unit process evaluation.

System Operating Data Screen

With information on the type and configuration of the plant being evaluated entered, the computer next asks the user for more specific information on the size of the unit processes and the wastewater being treated. Figure 13 shows the information requested on the system operating data screen. The user proceeds through the 12 lines of information entering data for each one. Data must be provided for each line or the computer will not allow the user to proceed through the major unit process evaluation.

Sludge Handling Processes Screens

Depending on the sludge handling processes previously entered on the component selection/system configuration screen, the computer will next provide the user the appropriate sludge handling processes screens. There are eight different processes, each with a separate screen, as shown in Figure 14. Some of the screens require the selection of a sludge feed type as the first entry. The choices are presented in the box on the screen.

Output Selection Screen

With all the data entered, the computer next presents the user with the four options shown in Figure 15 for displaying the results of the major unit process evaluation.

POTW Name: POTW Type:

Yearly Average Daily Wastewater Flow (gpd)
Min. Month Average Daily Wastewater Flow (gpd)
Peak Month Average Daily Wastewater Flow (gpd)
Influent BOD-5 (mg/l)
Primary Effluent BOD-5 (mg/l)
Final Effluent BOD-5 Desired (mg/l)
Aeration Basin Volume (gal)
Oxygen Transfer Capacity (lb/d)
Secondary Clarifier Surface Area (sq ft)
Secondary Clarifier Depth at Weirs (ft)
Minimum RAS Flow (gpd)
Maximum RAS Flow (gpd)

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Figure 13. System Operating Data Screen.

Gravity Thickener Screen

POTW Name: POTW Type:

Gravity Thickener Sludge Feed
Gravity Thickener Surface Area (sq ft)
Gravity Thickener Rating (lb/d/sq ft)
Feed Sludge Concentration (percent)
Output Sludge Concentration (percent)

SLUDGE FEED	1 Primary Sludge 2 Secondary Sludge 3 Primary + Secondary Sludge

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

DAF Thickener Screen

POTW Name: POTW Type:

DAF Sludge Feed
DAF Surface Area (sq ft)
DAF Rating (lb/d/sq ft)
Feed Sludge Concentration (percent)
Output Sludge Concentration (percent)

SLUDGE FEED	1 Primary Sludge 2 Secondary Sludge 3 Primary + Secondary Sludge

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Figure 14. Sludge Handling Processes Screens.

(continued)

Anaerobic Digester Screen

POTW Name: POTW Type:

Anaerobic Digester Sludge Feed
Anaerobic Digester - Number of Stages
Anaerobic Digester Volume (gal)

SLUDGE FEED	1 Primary Sludge 2 Secondary Sludge 3 Primary + Secondary Sludge

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Aerobic Digester Screen

POTW Name: POTW Type:

Aerobic Digester Sludge Feed
Aerobic Digester Volume (gal)

SLUDGE FEED	1 Primary Sludge 2 Secondary Sludge 3 Primary + Secondary Sludge

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Figure 14. (continued)

(continued)

Belt Filter Screen

POTW Name: POTW Type:

Belt Filter Sludge Feed
Belt Filter Rating (lb/hr)
Belt Filter Operation (hr/wk)

SLUDGE FEED	1 Primary Sludge 2 Secondary Sludge 3 Primary + Secondary Sludge

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Vacuum Filter Screen

POTW Name: POTW Type:

Vacuum Filter Sludge Feed
Vacuum Filter Surface Area (sq ft)
Vacuum Filter Rating (lb/sq ft/hr)

SLUDGE FEED	1 Primary Sludge 2 Secondary Sludge 3 Primary + Secondary Sludge

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Figure 14. (continued)

(continued)

Drying Beds Screen

POTW Name: POTW Type:

Drying Bed Total Surface Area (sq ft)
Maximum Depth of Sludge in Beds (in)
Worst Season Bed Turnover Time (days)

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Sludge Lagoons Screen

POTW Name: POTW Type:

Sludge Lagoons Total Volume (gal)

[Esc] to Abort---[PgDn] For Next Screen---[PgUp] For Previous Screen

Figure 14 (continued).

Press [Return] for Output to Printer

Press [Tab] for Output to Screen

Press [Esc] to Change/Add Data

Press [Space Bar] to Save Data for Later Printing

Figure 15. Output Selection Screen.

Save Data Screen

When the user chooses to "Save Data for Later Printing" from the output selection screen, the computer provides the save data screen shown in Figure 16. This screen allows the user to "save data as" the current file name or save it under a new file name. As described in attachment B, this allows the user to make comparisons between the original plant and one with different unit processes, operation schedules, and/or flow data.

Example Output from Program

Figure 17 shows an example major unit process evaluation computer program output for an activated sludge plant. The first page presents the data on which the evaluation was completed. On the second page, the point scores for each major unit process evaluated is presented as well as the type of plant.

THE NEED FOR JUDGEMENT IN CONDUCTING A CPE

The person completing a CPE assumes responsibility for determining the performance capability of the major unit processes at the plant, identifying and prioritizing the factors limiting its performance and assessing whether or not a CCP will bring the plant into compliance without major construction. In assuming this responsibility, the evaluator must use his or her judgement to assure the accuracy of the CPE.

A microcomputer, using the program described above, can assist in completing the major unit process evaluation portion of the CPE, but the evaluator must ultimately judge the validity of the results generated by the computer. The computer program is based on the point scores in the Handbook (12). These point scores have been found to generally provide

SAVE DATA AS: (Y/N)

Figure 16. Save Data Screen.

POTW MAJOR UNIT PROCESS EVALUATION
04-22-1986

POTW Name: SEMINARC

Conventional Activated Sludge

with:

Aerobic Digestion of Secondary Sludge
Belt Press Filtration of Secondary Sludge
Capability to Measure RAS Flows

Average Daily Wastewater Flow = 2,740,000 gpd
Min. Month Average Daily Wastewater Flow = 2,370,000 gpd
Peak Month Average Daily Wastewater Flow = 3,410,000 gpd

Raw Wastewater BOD-5 = 192 mg/l
Final Effluent BOD-5 = 15 mg/l

Aeration Basin Volume = 911,250 gallons
Oxygen Transfer Capacity = 7,600 lb/d

Secondary Clarifier Surface Area = 5,655 sq ft
Secondary Clarifier Depth at Weirs = 9 ft

Minimum RAS Flow = 360,000 gpd
Maximum RAS Flow = 3,600,000 gpd

Aerobic Digester Volume = 1,044,502 gallons
Belt Filter Rating = 700 lb/hr

Secondary Clarifier is Circular with Weirs on Walls

RAS Removal is Rapid Withdrawal from Circular Clarifier

Sludge Volume Metered and Hand Sampled

Figure 17. Example Output.

(continued)

```
**********************************************************************
AERATION BASIN

Hydraulic Detention Time =   6.4 hours
Organic Loading =  36.0 lb BOD-5/d/1,000 cu ft
Oxygen Availability =   1.7 lb Oxygen/lb BOD-5
----------------------------------------------------------------------
Hydraulic Detention Time Point Score          2
Organic Loading Point Score                   3
Oxygen Availability Point Score               6

        Aeration Basin Subtotal              11 ( TYPE 2 )
**********************************************************************

**********************************************************************
SECONDARY CLARIFIER

Surface Overflow Rate = 603 gpd/sq ft
Recommended RAS Flow Range =     592,500 -  2,557,500 gpd
Actual RAS Flow Range      =     360,000 -  3,600,000 gpd
Clarifier Depth at Weirs = 9 ft
----------------------------------------------------------------------
Clarifier Configuration Point Score           7
Surface Overflow Rate Point Score             7
Depth at Weirs Point Score                   -3
RAS Removal Method Point Score               10
RAS Control Point Score                      10

        Secondary Clarifier Subtotal         31 ( TYPE 1 )
**********************************************************************

**********************************************************************
SLUDGE HANDLING CAPABILITY

Total Sludge Mass Expected =   4,297 lb/d

Total Sludge Volume Expected =   85,871 gpd ( 0.6 % solids)

Aerobically Digested Total Sludge Volume =   28,664 gpd ( 1.3 % solids)

Aerobically Digested Total Sludge Mass =   3,179 lb/d

Total Digested Sludge Volume =   28,664 gpd ( 1.3 % solids)

Total Digested Sludge Mass =   3,179 lb/d

Aerobic Digester Detention Time =  12.2 days ( 81 percent)

Belt Filter Loading =   22,253 lb/wk
Belt Filter Operation Required =  32 hr/wk ( 125 percent)

Limiting Sludge Capacity =  81 percent
----------------------------------------------------------------------
Sludge Controllability Point Score            3
Sludge Capacity Point Score                   3

    Sludge Handling Capability Subtotal       6 ( TYPE 2 )
**********************************************************************


**********************************************************************
        Total Points                         48 ( TYPE 2 )
**********************************************************************

                POTW IS TYPE 2
```

Figure 17 (continued).

an accurate rating of the capability of the various unit processes, but they must not be taken as gospel. The evaluator must always question whether or not the point scores and plant types generated by the computer accurately reflect what has been observed at the plant. Some plants might have unit processes that receive high scores because of the criteria in the Handbook but the evaluator still considers inadequate and vice versa. In these cases, the evaluators judgement should prevail over any calculations performed by the computer.

Judgement is especially needed for evaluating borderline plants where the point scores are only a few points either way of being type 1 or 2 or type 2 or 3. The computer does not make these distinctions; labeling the plant only one of the three types. In these cases, however, the evaluator is responsible for deciding whether the borderline unit processes are actually capable of producing an acceptable effluent if a CCP is implemented at the plant.

Completing a major unit process evaluation alone does not constitute a CPE. Identifying and prioritizing the performance limiting factors is as important as the major unit process evaluation. This part of the CPE relies entirely on the evaluator's judgement.

The evaluator can not assess the ability of a CCP to bring a plant into compliance without confidence in the results of the major unit process evaluation and the prioritized list of performance limiting factors. This confidence only comes from the evaluator using his or her judgement to assure the accuracy of the CPE.

CPE'S AND TECHNICAL ASSISTANCE

In the original survey of factors limiting the performance of 103 municipal wastewater treatment plants, improper technical guidance was ranked No. 5 out of the 70 factors evaluated. The improper technical guidance was provided by all types of authoritative sources. At any one plant, it came from several sources which often added further confusion. An evaluator conducting a CPE at a plant can easily supply improper technical guidance in an honest attempt to improve performance.

The evaluator's responsibility in conducting a CPE is to identify the unique combination of design, operation, maintenance, and administrative factors limiting the performance at that plant. This is followed by an assessment as to ability of a CCP to bring the plant into compliance.

Problems with providing improper technical guidance begin when the evaluator begins attempting to solve the performance problems during the CPE. Correction of the performance limiting factors requires a CCP where a facilitator has long term involvement (12 to 18 months) with the plant. This long term involvement, as described previously, stems from the fact that there are no quick solutions to performance problems. The facilitator works with plant staff to correct design deficiencies, set process control direction, and assists them in implementing the necessary process control. During the 12-18 months, the facilitator follows up with the plant staff to make sure these decisions are correct and to transfer the process control capability. This long term involvement and follow up are not possible in the three to five days of a CPE.

Improper technical guidance can occur during a CPE if the evaluator gives specific recommendations to the plant staff that are not followed

up with to make sure they are appropriately applied. These recommendations can be taken as gospel and used even when conditions in the plant drastically change.

A CPE can certainly provide meaningful technical assistance to a municipality experiencing performance problems at their plant. The evaluator, however, must only identify the factors limiting performance and assess the ability of a CCP to bring the plant into compliance. Great care must be given to not providing specific recommendations during a CPE. These recommendations, though provided in an honest attempt to improve performance, may ultimately prove to be improper technical guidance and limit the performance of the plant. Conditions at the plant will change after the CPE, and without follow-up by the evaluator, appropriate changes in the original recommendations may not be made.

SUMMARY

The comprehensive performance evaluation (CPE) is a systematic approach for evaluating the factors limiting a municipal wastewater treatment plant's performance and assessing the ability of a composite correction program (CCP) to bring it into compliance. A microcomputer using the program described in this paper can assist in completion of the major unit process evaluation part of the CPE. The CPE, however, consist of several other parts which rely entirely on the evaluator's judgement. While the microcomputer can assist in completing a CPE it can not replace the knowledge, experience, or judgement of the CPE evaluation.

A CPE will provide a municipality with valuable technical assistance regarding the factors preventing their wastewater treatment from achieving compliance. Achieving compliance, however, will require correction of all the factors limiting their facilities performance by implementing a CCP.

DISCLAIMER

"This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication."

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Attachment A

ORDERING INFORMATION

POTW MAJOR UNIT PROCESS
EVALUATION COMPUTER PROGRAM

Forward this form and a blank double-sided 5-1/4" IBM-compatible diskette to:

Denis Lussier
US EPA
CERI
26 W. St. Clair Street
Cincinnati, OH 45268

The program will be copied onto your diskette (at no charge) and the diskette will be returned with accompanying instructions for setup and use.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____STATE_____ZIP_____

Attachment B

POTW MAJOR UNIT PROCESS EVALUATION COMPUTER PROGRAM

INTRODUCTION

This document presents information for use of a computer program (the CPE Program) that performs all the calculations required to evaluate major unit processes of Publicly Owned Treatment Works (POTW) according to the methods described in the U.S. Environmental Protection Agency's Technology Transfer Handbook for Improving POTW Performance Using the Composite Correction Program Approach (EPA-625/6-84-008). The results of this evaluation determine the applicability of the Composite Correction Program (CCP) to improving the performance of the POTW being evaluated.

No attempt should be made to use this program without a complete understanding of the POTW evaluation process and performance improvement concepts contained in the CCP Handbook. The major unit process evaluation is only one portion of the overall approach to POTW improvement and the user must be aware of the other steps involved. This program is not to be used for design of new treatment systems. A copy of the CCP Handbook can be obtained by writing: U.S. EPA, CERI, 26 West St. Clair, Cincinnati, OH 45268.

This computer program is intended to be used in lieu of Appendices L through O in the CCP Handbook. The same limitations apply to the program as to the Handbook, i.e., it is for common biological processes: activated sludge, trickling filters, rotating biological contactors (RBCs), and activated biofilters (ABFs). In addition, application is intended for POTWs less than 40,000 m^3/d (10 mgd).

EQUIPMENT NEEDS

The following hardware/software items are the minimum required to run the CPE Program:

1. IBM Personal Computer with 256K memory
2. One Double Sided Disk Drive
3. PC-DOS 2.1
4. IBM Monochrome Display Adapter
5. Monochrome Display

The program was developed for use on the minimum system itemized above. The user can add a printer (recommended) and/or a color monitor. The program has not been tested on an IBM-compatible computer with the same minimum system requirements listed above; it has only been verified on the IBM-PC, IBM-AT, and IBM Portable.

SETTING UP YOUR SYSTEM

Type only the commands given in bold print. Capitalization is not required unless so indicated. [ ] indicates a key that should be pressed. You should make a backup copy of the CPE Program Master Diskette and use the copy to perform the following. Separate instructions are given for a PC with one floppy drive, a PC with two floppy drives, and a PC with a hard disk.

PC with One Floppy Drive

1. Type DISKCOPY [Enter]. Follow the screen prompts to make a copy of your DOS Disk, using the DOS Disk as the source disk and a blank disk as the target disk. At the query "Copy another (Y/N)?", type N. Remove the DOS Copy and label it "CPE Disk".

2. Reinsert the CPE Disk in the disk drive.

3. Type the following .

   COPY CON: AUTOEXEC.BAT [Enter]

   There will no response from the system at this point.

4. Type the following commands. The CPE in quotes must be capitalized.

   DATE [Enter]
   TIME [Enter]
   DIR¦FIND " CPE "¦SORT>CPESORT [Enter]
   BASICA CPEMENU [Enter]
   [F6] [Enter] (The screen shows ^Z when the [F6] key is depressed)

   The system should show "1 File(s) copied".

5. Type BASICA [Enter].

   The screen should now show:

```
The IBM Personal Computer Basic
Version A2.10 Copyright IBM Corp. 1981, 1982, 1983
xxxxx Bytes Free

OK
```

6. Insert the CPE Program Master Disk and type RUN"SINGLEDD [Enter].

   At the prompt, reinsert the CPE Disk and press [Enter]. The A> prompt will appear on the screen when the program is finished.

7. Type BASICA [Enter]

   The screen should again show:

```
The IBM Personal Computer Basic
Version A2.10 Copyright IBM Corp. 1981, 1982, 1983
xxxxx Bytes Free

OK
```

8. Replace the CPE Disk with the CPE Program Master Disk.

9. Type LOAD"CPEMENU [Enter]

   The system should show "OK".

10. Replace the CPE Program Master Disk with the CPE Disk.

11. Type SAVE"CPEMENU [Enter]

    The system should show "OK".

12. Replace the CPE Disk with the CPE Program Master Disk.

13. Type LOAD"CPEMAIN [Enter]

    The system should show "OK".

14. Replace the CPE Program Master Disk with the CPE Disk.

15. Type SAVE"CPEMAIN [Enter]

    The system should show "OK".

16. Replace the CPE Disk with the CPE Program Master Disk.

17. Type LOAD"CPEPRINT [Enter]

    The system should show "OK".

18. Replace the CPE Program Master Disk with the CPE Disk.

19. Type SAVE"CPEPRINT [Enter]

20. Store the CPE Program Master Diskette in a safe place.

21. Type SYSTEM [Enter]

    The screen should show the A> prompt.

22. Type DIR [Enter]. The system should show that you have the following files on your disk.

    COMMAND.COM
    CPEMENU.BAS
    CPEMAIN.BAS
    CPEPRINT.BAS
    SORT.EXE
    FIND.EXE
    BASICA.COM
    AUTOEXEC.BAT

    If you have more than these files, delete the extras. If you have less, run the setup procedure again.

23. To run the CPE Program, either hold down the [Ctrl], [Alt], and [Del] keys at the same time, or type AUTOEXEC [Enter].

To run the CPE Program at a future time either: 1) with the computer off, insert your "bootable" CPE disk in the disk drive and turn your computer on; or 2) with the computer on and the A> prompt on the screen, insert the CPE Disk in the disk drive and either hold down the [Ctrl], [Alt], and [Del] keys at the same time, or type AUTOEXEC [Enter].

PC with Two Floppy Drives

1. Insert your DOS diskette in Drive A and turn your computer on.

2. After the date and time prompts are answered and the A> prompt appears, type FORMAT B:/S [Enter].

3. Insert a blank diskette in Drive B and [press any key].

4. At the query "Format another (Y/N)?", type N.

5. At the A> prompt, type COPY BASICA.COM B: [Enter].

   The system should show "1 File(s) copied".

6. Type COPY SORT.EXE B: [Enter].

   The system should show "1 File(s) copied".

7. Type COPY FIND.EXE B: [Enter].

   The system should show "1 File(s) copied".

8. Remove the DOS diskette from Drive A and insert the CPE Program Master Diskette in Drive A.

9. Type COPY AUTOEXEC.BAT B: [Enter].

   The system should show "1 File(s) copied".

10. Type COPY *.BAS B: [Enter].

    The system should show the following:

```
A:CPEMENU.BAS
A:CPEMAIN.BAS
A:CPEPRINT.BAS
        3 File(s) copied
```

11. Remove the CPE Program Master Diskette and store it in a safe place.

12. Remove the "bootable" CPE Program diskette from Drive B and label it "CPE Disk".

13. To run the CPE Program, make sure your "CPE Disk" is in Drive A and either hold down the [Ctrl], [Alt], and [Del] keys at the same time, or type AUTOEXEC [Enter].

To run the CPE Program at a future time either: 1) with the computer off, insert the CPE Disk in Drive A and turn your computer on; or 2) with the computer on and the A> prompt on the screen, insert the CPE Disk in Drive A and either hold down the [Ctrl], [Alt], and [Del] keys at the same time, or type AUTOEXEC [Enter].

PC with Hard Disk

Note: the screen responses indicated below are for an IBM-AT. You may receive slightly different responses on another computer.

1. Turn your computer on. You should see the C> prompt.

2. Insert the CPE Program Master Diskette in Drive A.

3. Type MD\CPE [Enter].

4. Type CD\CPE [Enter].

   The screen should show C:\CPE>.

5. Type COPY A:CPE.BAT [Enter].

   The system should show "1 File(s) copied".

6. Type COPY A:*.BAS [Enter].

   The system should show the following:

```
A:CPEMENU.BAS
A:CPEMAIN.BAS
A:CPEPRINT.BAS
        3 File(s) copied
```

7. Remove the CPE Program Master Diskette and store it in a safe place.

8. To run the CPE Program, type CPE [Enter].

To run the CPE Program at a future time, you must go to the CPE subdirectory by typing (at the C> prompt) CD\CPE [Enter]. Then type CPE to begin program execution.

HOW THE PROGRAM WORKS

The CPE Program contains a series of screens that prompt the user to enter information. Based on the information entered, the program then determines whether the POTW being evaluated is a Type 1, Type 2, or Type 3 facility. The significance of this determination of POTW Type is explained in Chapter 2 of the CCP Handbook.

DATA REQUIRED

The data required to complete the major unit process evaluation are obviously different for each POTW configuration. In the program flow, the user first enters the POTW name, treatment system type, and system components (three separate screens). Each subsequent screen after these three is determined by this initial treatment system type and system components data.

Appendix D of the CCP Handbook contains all the forms necessary to acquire the additional (operating) data required to complete the major unit process evaluation. Most of these data must be collected at the plant site.

DATA ENTRY

The screens that will appear during program execution are explained below. Only those screens that apply to your POTW configuration will be displayed. The user can restart the program at any time during the data entry phase by pressing the [Esc] key: any data entered will be lost. The keys [PgDn] and [PgUp] move the user to either the next or previous screen: any data entered on the screen being exited is saved. When data to be entered are numeric values, enter only numbers (and decimal points if required). Entering commas will cause the value to be truncated to the numbers before the comma.

Selection Menu Screen

Selection 1: Choose this selection to change data entered for an evaluation already completed. If you choose this selection and no files exist, the program restarts.

Selection 2: Choose this selection to evaluate a POTW for the first time.

Selection 3: Choose this selection to return to the computer operating system.

Selection 4: Choose this selection to delete a previously completed evaluation.

Selection 5: Choose this selection to printout evaluation results only. You must have chosen selection 1 or 2 at some previous time and saved the data.

FILE NAME Screen

This screen only appears if you selected either "Edit Old Evaluation", "Delete File", or "Printer Output of Old Evaluation" from the Selection Menu screen. You must enter one of the file names listed on this screen.

POTW NAME Screen

This screen only appears if you selected "New Evaluation" from the Selection Menu screen. Enter the name of your choice for the POTW being evaluated. The program will truncate the POTW name to a file name of 8 characters in length.

POTW Type Screen

Enter a number from 1 to 7 indicating the type of treatment system being evaluated. The choices are displayed in the box at the bottom of the screen.

Component Selection/System Configuration Screen

Enter a Y or N to indicate whether the unit processes on this screen are part of your POTW configuration. Also, depending on your system, you may have to reply Y or N to these items:

Secondary Sludge to Primary: Is secondary sludge returned to the primary and the combined sludge removed from the primary for treatment and disposal?

Ability to Measure RAS Flows: Is the capability to measure return activated sludge present in your system?

Return Sidestreams Ahead of TF/RBC: Is supernatant from anaerobic digesters or filtrate/concentrate from dewatering returned to the wastewater stream ahead of the TF/RBC unit?

The following items require numbers as data entry. The choices are indicated in the box at the bottom of the screen. Again, depending on your system, you may not have to reply to all these items.

Final Clarifier Configuration: Enter a number from 1 to 5 indicating the configuration of your final clarifier.

RAS Removal Method: Enter a number from 1 to 5 indicating the final clarifier sludge removal mechanism.

Sludge Controllability: Enter a number from 1 to 4 indicating the type of waste sludge sampling and measurement available in your system.

System Operating Data Screen

The parameters and units required are indicated. You must enter data for each parameter listed before you will be allowed to move to another screen. "Final Effluent BOD-5 Desired" is the effluent quality you are trying to get out of the POTW. For example, if the permit limit was 30 mg/l BOD-5, you would want to have the POTW consistently produce an effluent somewhat lower. The rationale behind this is that you must make allowances for those times when the POTW does not perform as expected due to higher flows, stronger influent, etc.

Gravity Thickener Screen

Gravity Thickener Sludge Feed: Enter a number between 1 and 3. The box at the bottom of the screen indicates the choices.

Gravity Thickener Surface Area: Enter the total surface area for all gravity thickeners.

Gravity Thickener Rating: Enter a value reflecting the actual capacity of the gravity thickeners. For a new evaluation, a value is given for your use if you are unsure of the actual capacity. This default value is based on your selection of sludge feed.

Feed Sludge Concentration: Enter the solids concentration of the sludge being gravity thickened. For a new evaluation, a calculated value based on sludge feed type, wastewater flow, and wastewater concentrations is given. Enter a different value if you feel this calculated value is not representative of the sludge being thickened.

Output Sludge Concentration: Enter the solids concentration expected in the thickened sludge. For a new evaluation, a value is given based on the sludge feed type. Enter a different value if you have knowledge that the thickeners produce a different quality sludge.

DAF Thickener Screen

See explanation above for gravity thickening.

Anaerobic Digester Screen

Anaerobic Digester Sludge Feed: Enter a number between 1 and 3. The box at the bottom of the screen indicates the choices.

Anaerobic Digester - Number of Stages: Self explanatory.

Anaerobic Digester Volume: Enter the total anaerobic digestion volume, in gallons.

Aerobic Digester Screen

Aerobic Digester Sludge Feed: Enter a number between 1 and 3. The box at the bottom of the screen indicates the choices.

Aerobic Digester Volume: Enter the total aerobic digestion volume.

Vacuum Filter Screen

Vacuum Filter Sludge Feed: Enter a number between 1 and 3. The box at the bottom of the screen indicates the choices.

Vacuum Filter Surface Area: Enter the total vacuum filtration surface area.

Vacuum Filter Rating: Enter a value representing the existing capability of the vacuum filters to process sludge. This value may be the manufacturer's rating, actual operating data, etc.

Belt Filter Sludge Feed

Belt Filter Sludge Feed: Enter a number between 1 and 3. The box at the bottom of the screen indicates the choices.

Belt Filter Rating: Enter a value representing the existing capability of the belt filters to process sludge. This value may be the manufacturer's rating, actual operating data, etc.

Belt Filter Operation: Enter the number of hours the belt filters are in operation per week.

Drying Beds Screen

Drying Bed Total Surface Area: Self explanatory.

Maximum Depth of Sludge in Beds: Enter a value representing the maximum depth to which sludge can be poured.

Worst Season Bed Turnover Time: Enter a value representing the longest amount of time required to adequately dry the sludge in the beds.

Sludge Lagoons Screen

Sludge Lagoons Total Volume: Enter the total volume of all existing sludge lagoons.

Output Selection Screen

Press [Return] for Output to Printer: This choice directs output to a parallel printer to produce hard copy of the major unit process evaluation.

Press [Tab] for Output to Screen: This choice directs the major unit process evaluation output to the monitor.

Press [Esc] to Change/Add Data: This choice repositions you at the start of the data entry portion of the program. Previously entered data will appear on each screen as you proceed through the program again.

Press [Space Bar] to Save Data for Later Printing: This choice saves the raw data entered in a file for later printing. By running the CPE Program and choosing selection number 5 on the Selection Menu Screen, you can have a hard copy of the major unit process evaluation without going through each screen.

Save Data Screen

This screen does not appear if you selected "Change/Add Data" from the Output Selection Screen. There are only 2 choices: save the data entered in the default file presented; or enter a file name of your choice. This gives you the option of recalling an old evaluation, changing some of the data, and storing all the data in a new file. You cannot use the [Esc] key at this point in the program; you must save the data.

For example, you may wish to compare the evaluation of your POTW with a belt filter operation of 30 hours a week with the evaluation for belt filter operation of 40 hours per week. To do this, proceed through the program entering all the data for the plant and save it using one of the options on the Output Selection Screen. Next, run the program again using the "Edit Old Evaluation" selection. Proceed to the Belt Filter Screen and change the value previously entered for Belt Filter Operation, e.g., from 30 to 40.

When you reach the Save Data Screen, respond N to the initial query and enter a new file name when asked. The major new unit process evaluation will be output or saved depending on your output selection choice.